

# FROZEN FOOD TECHNOLOGY AND PACKAGING

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WE have come a long way from the standard menu of our grandfathers' day—the bread, meat, potatoes, pie and coffee diet—as everyone must realise.

Many facets of our living have changed, even since the days of the first world conflict, and a number of these changes appear to have aided significantly in spawning and in nurturing the lusty new food industry which is concerned with the development and marketing of frozen food products, and which is an endeavour in which some \$5.5 billion is invested directly, in the U.S. alone.

Urbanisation with the attendant movement of large percentages of population from the land to the city, congested living with loss of garden space, the substitution of diminutive kitchens for the ample food preparation centers of our forebears, emancipation of the feminine gender from household drudgery, an increasing participation of women in the labour force, a levelling-out of social and educational opportunities, restricting the availability of domestic help, higher average incomes, improved transport, engineering advances, technological improvements—all these and many more have set the stage for frozen foods.

Frozen foods are appealing because of their convenience. Many require only simple heating and seasoning prior to eating, while others require heating only, and all greatly simplify the chores of food preparation.

The convenience of frozen foods is valuable not only in the individual household but also in many institutional situations. In clubs, hospitals, hotels, trains and planes, the freedom from waste which characterises frozen foods restricts the dimensions needed for costly preparation areas, provides a more uniform product, enhances portion control, eases waste disposal, affords diet diversification, places less dependence on costly culinary staff, and demonstrates other unique values.

Many frozen foods are appealing because of their superior colour, their fresh-like flavour, and the variety they can add to otherwise routine meals. Freezing preservation is important in smoothing out the surpluses and lacks of many classes of perishable commodities. All the world becomes one's larder: exotic foods in an increasing degree can be brought to the average table.

The precept of the "balanced meal" with its admonitions to use "the root, leaf and pod" which has been the earnest plea of the nutritionists for so many years, is now within easy reach of us all in spring, summer, fall and winter, thanks to refrigerated

storage and to frozen foods. Vegetables, you will recall, as well as many delectable fruit products, did not form, prior to the turn of the century, an important percentage of the American diet; at least not in the urban areas.

Without question, the food habits and the culinary habits of our nations have been affected for the better by frozen foods. As evidence of these changes we need note only what has happened in one food group, namely, the vegetables.

## 300% Increase

Within the recent decade from 1945 to 1955, the consumption of frozen vegetables, such as peas, spinach, green beans, carrots and like crops, rose from a half billion lb. per year (1945) to nearly two billion lb. by the end of 1955.<sup>1</sup> Making due allowances for the increase in population, it is still possible to say that the increase in consumption of these nutritious foods in that decade is of the order of 300%.

Consider also the magnificent vegetable farms that directly supply the industry in the U.S. and Canada, and you have visible evidence of the influence that frozen foods have upon our agricultural economy. Even if we recognise that other forms of preservation, such as canning, dehydration, pickling and fermentation, have also contributed, with fresh foods, to this substantial increase in the consumption of vegetables, the frozen food industry can still lay claim to having added materially to the consumption of these commodities in the U.S. and Canada.

It must be well known that the frozen food industry began with the late Clarence Birdseye, in Hillsboro, Oregon, in 1929,<sup>7</sup> slightly less than three decades ago. Initial advances in technology were concerned with improving the quality of frozen fish. Such work was initiated as early as 1925. Vegetables, especially lima beans and green peas came into the picture in the early 1930's. The fruits first frozen using the new techniques were principally berries of several types. Frozen strawberries are today one of the most important items in point of volume, reaching levels approximating those of green pea packs, which run to some 230 million lb. annually.

More recently we have seen the advent of fish sticks, shellfish, frozen meats, entrée dishes and pre-cooked items, as well as outstanding specialties packaged in strikingly novel types of containers.

It is estimated that today in the U.S. alone, some 700 different types of frozen food items are available, being produced by approximately 900 companies.

An appreciable percentage of this business is in the hands of a few large companies, whose mass sales and national brands dominate the market. For instance, 43% of the total volume of fruits and vegetables marketed as frozen products are in the hands of less than 2% of the firms.<sup>4</sup>

The total volume of frozen foods is estimated variously as ranging between 10 billion and 14 billion lb. annually, in the U.S. The largest commodity class is comprised of the vegetable packs, which average about 10% of total sales. Frozen citrus concentrates, about equal in volume to all other classes of frozen-fruit packs, account for some 5 to 6% of total volume. The pre-cooked TV dinner type of commodity and other pre-cooked items run to about an additional 10%, and their volume is increasing continuously.

Illustrative of the vast volume of sales possible when a new type of food "catches on" are those referable to the citrus juice concentrates, of which in the year 1948-49, some 12 million gall. only were marketed, increasing in less than 10 years almost 800%, to more than 92 million gall. in 1956-7.<sup>2</sup>

The quality level of frozen foods is being improved continuously. Nationally advertised products are expected to be similar between various packs thereof, and in different localities. Only by adherence to strict standards can inherent raw product differences be ironed out. As volume increases the problems underlying maintenance of uniform quality become increasingly important, and place obligations alike upon the farmer, the processor and the distributor.

In general, fruits and vegetables used for the production of frozen packs are harvested at near to prime ripeness, in contrast to the "firm-ripe" stage preferred for canned products, and hence frozen packs are endowed with more of the flavour, colour and aroma characteristics of the fresh fruits or vegetables. Freezing preservation accompanied by proper packaging and protectants, preserves almost indefinitely the aroma, taste, flavour and vitamin content of a majority of the items.

A recent comprehensive study by the Wisconsin Alumni Research Foundation (of Madison, Wisconsin), embracing 51 different fruits, vegetables and juices, concluded that: "... in general, frozen foods furnish high levels of vitamin C, good levels of the B vitamins, vitamin A, and protein, and appreciable amounts of calcium, phosphorus and iron."

Frozen foods are nutritious and palatable.<sup>3</sup> The broad array of frozen foods available and the very substantial volumes consumed annually, would suggest that such foods have been in our mutual dietary for a long time. Actually, however, a majority of the processing methods and of the pertinent product development has occurred only during the past 25 or 30 years.

By refinements in the systems of refrigeration—the compression system, the flooded system, the absorption system—and by the use of new or improved refrigerants, as distinct from ice-systems, it has become possible to get increasingly better control

of heat transfer, and to withdraw heat from foods in accordance with the freezing requirements of specific products.<sup>6</sup>

### New Technical Terms

Amongst new technical terms, clustering around the advances in refrigeration engineering, are *sharp freezing*, introduced during the first year of the civil war, and *quick freezing*.

*Sharp freezing* consists of placing products in the still air of cold rooms, maintained at temperatures varying from  $+5^{\circ}\text{F.}$  to  $-20^{\circ}\text{F.}$

*Quick freezing* in its modern sense means solidification by freezing, within a very short interval of time, proceeding through the body of the product at a rate of somewhat more than 1 in. per min., as suggested by Woodruff several years ago (3 cm. per min.).

These terms, still in use, like all technical terms, have an original context that embraces agonised and often frustrating experimental work.

Donald Tressler includes the following freezing techniques in his recent recapitulation of the subject.<sup>7</sup>

There are, he says, a number of ways to accomplish quick freezing, or, in more scientific terms, to remove heat. The food may be floated on pans on circulating brine, or may be frozen on flat metal plates beneath which brine flows, or it may be frozen between two moving or stationary cold plates.

There are also a great variety of air-blast freezers, and these are probably the most common type in use today. In still other processes, brine can be shot in a fine spray against either the food itself or against the package, or such products or packages can be submerged in brine or other refrigerating media.

So fertile have the engineers been in their innovations that a sensational 300 industrially-sound patents have been issued on freezing since 1930.

Recent engineering research has developed high-speed continuous freezers, either of the Patterson continuous plate type or those which, like the FMC (Food Machinery Corporation) continuous round-shell can freezer, may attain speeds up to 400 cans per min. These may be employed with automatic casing machines to effect very substantial savings in labour requirements.

Two interesting recent developments, of the many currently under study, pertaining to the frozen food industry, will be mentioned: these are "dehydrefreezing" and "freeze-dehydration".

*Dehydrefreezing* as the name implies, combines the processes of dehydration and freezing. The dehydration step removes a majority of the water—an amount which varies between product types—and thereby reduces volume and weight in very substantial degree.

Only the "easily removed" water is separated in this drying step. "Hard to remove" water, which often in traditional processes is evaporated only at the risk of gross quality deterioration, remains in the product. It is frozen in the succeeding freezing step.

This new process is similar in all of its aspects to traditional freezing preparation, with the exception of the interjection of a dehydrating step, just ahead

of the freezing of the finished product. Freezing may be done before or after packaging. Packaging is in the larger institutional types of containers of 30 lb. size or larger. It is noteworthy that at least twice the weight of many dehydrofrozen products can be packed in such containers, compared to traditionally frozen products, and shipping weight reductions may amount to as much as 70% of the weight of canned (tinned) items.

*Freeze dehydration* in contrast is a process requiring the freezing of the product *prior* to its desiccation, and drying occurs at freezing temperatures under high vacuum. Partial pressures in the chamber are a few  $\mu$  to a mm. or so of mercury. Dehydration is thus by sublimation or lyophilisation.

Fruit powders of superior quality are obtained by this method, as also are superior dehydrated meats, cooked or uncooked. Such products retain a surprising amount of their fresh flavour when reconstituted and consumed in normal diets.

Preservation of the end product developed in freeze dehydration is a function primarily of the extremely low moisture content attained. This is in the neighbourhood of 1.5%. These products are, of course, protected by appropriate packaging.

A majority of freeze-dehydrated products can be reconstituted almost instantly even in cold water.

A minimum of refrigeration is needed to maintain such products at a high level of quality over prolonged periods of time. Even ambient temperatures may be employed for considerable periods of storage without undue deterioration, provided that moisture is kept away from the products.

Seafoods of a most superior quality may be prepared by this process.

Preparation of freeze-dehydrated foods currently is expensive compared to other methods of freezing, but logistical advantages may be more than off-setting. Moreover, innovations in equipment and techniques give reason for considerable optimism that this method will attract real commercial interest in years to come.

The Food and Container Institute for the U.S. Armed Forces has contributed in a substantial way to the development of products using this process, and they are continuing to make marked improvements in the process.

### Economic Highlights and Trends

The production and distribution of frozen foods is big business. Annual sales currently approximate \$2.5 billion and indices of expansion suggest a doubling of this volume within 9 years.

It will be interesting to turn briefly to the capital structure of this industry, to examine its plant and service framework, look briefly at the picture of costs and profits, and consider how the homemaker's frozen food dollar is disbursed.

The present treatment of this enticing subject is cursory only, and there can be no attempt at this time to do more than point to a few of the fascinating economic highlights and trends.

Dr. H. Wayne Bitting, of the U.S. Department of

Agriculture, Marketing Service, has estimated that the U.S. frozen food industry represents a \$5½ billion investment, and total capital outlays for all frozen food processing plants, including frozen meats, seafood, poultry and prepared foods is around \$1 billion, according to his estimates.<sup>5</sup> Distributors, he believes, have an additional current investment of approximately \$460 million.

Protection by temperatures at or below 0°F. is essential to maintain the quality of frozen foods. This environment must be maintained at all stages from production to consumption. Great impetus has been given thereby to the ancillary industries which supply cold-storage facilities, refrigerated transports, frozen food lockers, low temperature display cases, deep-freezers and home-type refrigerators.

Refrigerated warehouses capable of supplying temperatures below 0°F. today have a capacity of approximately 400 million cu. ft., and represent an initial investment of the order of \$620 million. This figure does not include space used for storage of stocks for periods of less than 30 days. New space is building at a rate estimated to be 5% per year, calling for new capital of the magnitude of \$30 to \$35 million annually.

The frozen products are transported from processor to distributor and to retailer employing some 250,000 refrigerated trucks and rail cars. These together have an estimated value approximating \$1 billion. Refrigerated van-type trailers alone, with motive power essential to their movement, account for an original investment of some \$800 million. And a doubling of this fleet would appear to be necessary over the next 8 to 10 years, according to Bitting's studies.

In the thousands of supermarkets and independent retail outlets which merchandise frozen foods in the U.S., there are an estimated 350,000 units of refrigerated display cases. These represent an initial investment in excess of \$350 million. Add to this another \$100 million for back-room storage facilities and one has a figure of commanding proportions.

Whereas the sale of frozen products is said to give a greater gross profit, in terms of floor area occupied, than any other class of sales in retail food outlets, there is today, and probably will be in the future, inadequate low temperature display space to permit maximum potential sales, or the introduction of many promising new items.

Freezer capacity in the households of the United States is a very important element in the total picture of frozen foods distribution. Home freezer capacity is estimated by Bitting to equal 120 million cu. ft. with a holding capacity of 3.6 billion pounds of food, or from  $\frac{1}{3}$  to  $\frac{1}{2}$  of the annual combined commercial frozen food production of the entire country. Home storage facilities represent an investment of some \$2.4 billion, and, of course, relieve commercial storage of this burden and capital requirement.

Filling the home freezers of the United States is, of course, the ardent and primary desire of both the producer and distributor of frozen foods.

Emphasising the convenience of frozen foods, their freedom from fuss and waste, their general high quality, and almost infinite variety, the frozen food purveyors are claiming an ever-increasing share of the homemaker's food dollar.

What with soups from Pennsylvania, lobster tails from South Africa, Puerto Rican Lima beans, Minnesota green peas, Oregon strawberries and the like, not to mention frozen desserts, TV dinners or Pizza pies—even the most routine meal can be given an infusion of glamour.

It is interesting, in the light of the patent enthusiasm for frozen foods in the average American home, to inquire where the dollars spent thereon may ultimately find their way. Proximate information for four "typical" vegetables—peas, Lima beans, corn and spinach—has been gleaned from data supplied by the U.S. National Association of Frozen Food Packers.

The farmer who grows and who frequently delivers the produce receives approximately 18 cents of each frozen food dollar spent by the home maker. The processor of these items, who receives them, grades and cleans them, blanches, processes and packs them, and who in an increasing degree also stores them for prolonged periods of time, receives approximately 65 cents from each of the dollars which the housewife pays at the retail outlet, and forthwith pays out a majority of this income for materials, services and taxes. The wholesaler, distributor, and retailer jointly receive approximately 17 cents out of each dollar. Each of these individuals in turn pays out a majority of this income for services, utilities and taxes.

The frozen food business is for the most part a business of giants: mass sales and low mark-ups characterise all stages of the business. In the face of currently competitive circumstances one must enter this business in a very substantial way, or risk loss of capital. A recent estimate indicates that a distributor doing less than \$1 million in gross business per year cannot long survive unless he is specialised in an extreme degree.

Retail turnovers of stock are expected to occur at least 26 to 40 times per year, and products just emerging from the laboratory and pilot plants therefore find increasing difficulty in competition for scarce refrigerated display-space.

Processors require high levels of financial resources for both plant and working-capital purposes. Bitting stated recently that a manufacturer of frozen "French-fried" potatoes for instance, would require a minimum of \$1.5 million for plant investment and another \$1 million for working capital, to be in a position to enter this fast growing market.

Ever-increasing volumes of nationally advertised frozen foods place new demands on the processor and farmer to have available products of uniform quality. In as much as the servicing of working

capital involves appreciable expense, retail and wholesale buyers are firmly controlling their inventories at minimal levels, thus placing a growing burden on the producer, who now must maintain considerably more warehousing than heretofore. In the light of the important services performed by the producer, the 65 cents of each dollar which he receives is not a disproportionate share.

The producer expends his income roughly as follows, according to the National Association of Frozen Food Packers. The outlays for services and materials are in declining order of percentage magnitude.

<i>Services and Materials</i>	<i>Cents per dollar of income</i>
Wages and Salaries	16.24
Packaging materials and supplies	10.92
Federal, State and local taxes	9.80
Transportation	9.66
Warehousing	5.43
Advertising and promotion	5.04
Other business expense	8.40
Net profit after taxes	3.92

In individual cases there will of course be variance in the above values, but these are sufficiently accurate to demonstrate the kinds of payouts and profit realisations which are not uncommon in the frozen foods industry.

It would be possible to explore many more of the highly technical and interesting aspects of this burgeoning new industry, which shows its threads in the broad fabric of agriculture, engineering and commerce, but this is enough for a quick glimpse at some of the highlights.

Certainly the future development of this dynamic technology will add to our common diet not only the immediately available provender of our native lands, but will enliven these with the delightful new tastes of tropical fruits.

Frozen meats will become as commonplace as frozen vegetables are today. Our lives and our diets will be enriched by this thriving industry—built on the skills of a multitude of scientists and businessmen in many lands.

#### References

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